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Project: DZERO Solenoid Energization, Controls, Interlocks & Quench Protection

Doc. No: H961122A

Subject: Preliminary Electrical Safety Review of the DZERO Central Tracking Solenoid Energization, Controls, Interlocks, Quench Detection and Quench Protection Systems

The purpose of this note and its attachments is to introduce the DZERO superconducting solenoid energization, controls, interlocks and quench protection system for the purpose of submitting to a preliminary electrical safety review. The intention is to present and discuss those issues of importance to the Electrical Safety Review Committee. The entire system is under construction at this time. It has undergone various conceptual design and engineering reviews. It should be formally reviewed for electrical safety. The equipment can be viewed now; but the committee should plan on making a final inspection when the installation is finished and not yet operating.

Location of Equipment: The equipment to be reviewed is located in the DZERO Assembly Building (DAB). Most of it is in room 511 on the south side in the "power supply room". A high current dc bus runs from the room to the solenoid. The solenoid will be located in the assembly pit during initial commissioning; and then in the collision hall for normal operation.

Description of Equipment: The energization equipment consists of a 15 Volt, 5000 Amp power supply which is bused to a water cooled, air coil, common and differential mode pi filter. A free wheeling diode across the power supply output provides a discharge path around the power supply's thyristors. A clamping diode across the filter output limits the reverse voltage seen by the filter output capacitors. From the filter, the current is bused to a reversing switch for polarity control and then through a dump switch. Beyond the dump switch, a stainless steel dump resistor is permanently connected across the circuit. The dump switch's purpose is to disconnect the power supply, filter and reversing switch from the solenoid and dump resistor in certain situations. The dump resistor's purpose is to dissipate the energy stored in the solenoid during both quick discharges during solenoid quenches and slow discharges during normal shutdowns and polarity reversals. The dump resistor will dissipate energy during normal operation because of the voltage developed across the non-superconducting bus between the power supply room and the superconducting solenoid.

The power supply room equipment is interconnected with solid copper bus. Current density is limited to 1000 Amps per square inch. Beyond the power supply room, standard 1.9" OD X 1.1" ID water cooled bus is used. The water cooled bus and a few instrumentation cables (quench detector voltage taps) connect to the solenoid as follows: Two pairs of 5000 Amp dc buses exit the room to the north. One of the pairs turns east and follows a route to the solenoid staging position in the assembly hall pit. The other pair turns west and follows a route to the solenoid operating position in the collision hall. The pair of buses to be used is selected by copper bar straps in the power supply room.

The bus conductors are electrically insulated by PVC pipe jackets and routed in closed aluminum cable trays. The cable trays serve as electrostatic shields and filtered noise return paths. The trays are bonded to ground at the power supply frame and are insulated from ground everywhere else.

Controls are provided by a Texas Instruments programmable logic controller (PLC) system and interfaced to networked operators via Intellusion's Distributed Manufacturing and Control Software (DMACS). All interlocks and quench protection is hardwired and designed to be fail safe. The control system can monitor interlocks; but cannot override them.

Electrical Safety Considerations: The solenoid power supply operates at a maximum of 15 Volts during charging and about half that during normal operation. It delivers 5000 Amps of current to the solenoid. The Solenoid will store 5.6 mega-Joules of energy in its magnetic field during operation. This energy must be dissipated during a slow discharge or a fast dump. The review committee may be concerned with the following aspects of this installation:

1. Adequate conductor Sizes.
2. Adequate connections between conductors.
3. Adequate component ratings for high power components (ie. filter capacitors)
4. Adequate electrical safety to personnel and equipment.
5. Adequate quench detection and protection.

Supporting Documentation: The following documents are attached to this note to provide supporting information for this preliminary review:

1. Specification for Solenoid Energization, Controls, Interlocks and Quench Protection - D0 Engineering Note 3823.111-EN-418 latest Rev 11/25/96. This is a complete description of project including controls and interlocks.
2. Schematic - Top level schematic of entire system Dwg. # 3283-111-ED-330052 latest rev. 20 Aug 96
3. Plan view sketch of equipment installation.
4. Power Supply - Data sheet: PEI 150-5 Power Supply - A.T. Visser latest revision 5/1/93.
5. Filter - Design Report - Engineering Note R. Hance H960703A (dump analysis available on request - H960801A)
6. Filter - Component Ratings - Engineering Note R. Hance H960731A
7. Reversing Switch - Data sheet (source unknown) & controls schematic.
8. Dump Switch - Information sheet from original vendor (switch was surplus at SCC) - full manual available if needed.
9. Dump Resistor - Design Note - By Walt Jaskiorny -Engineering Note R. Hance H960814A. Includes mechanical sketch.
10. Dump Resistor - Engineering Review - Engineering Note R. Hance H960917B
11. Bus Connections, Bolts, Torque, Contact Area, Prep - Engineering Note R. Hance H961028A
12. Description of a Water Cooled Bus - By A.T. Visser - TM1372.

Additional Documentation: Much additional documentation is available including an index to documentation. The attached items were thought to be most useful to the review committee. Any additional information that is requested will be promptly provided.